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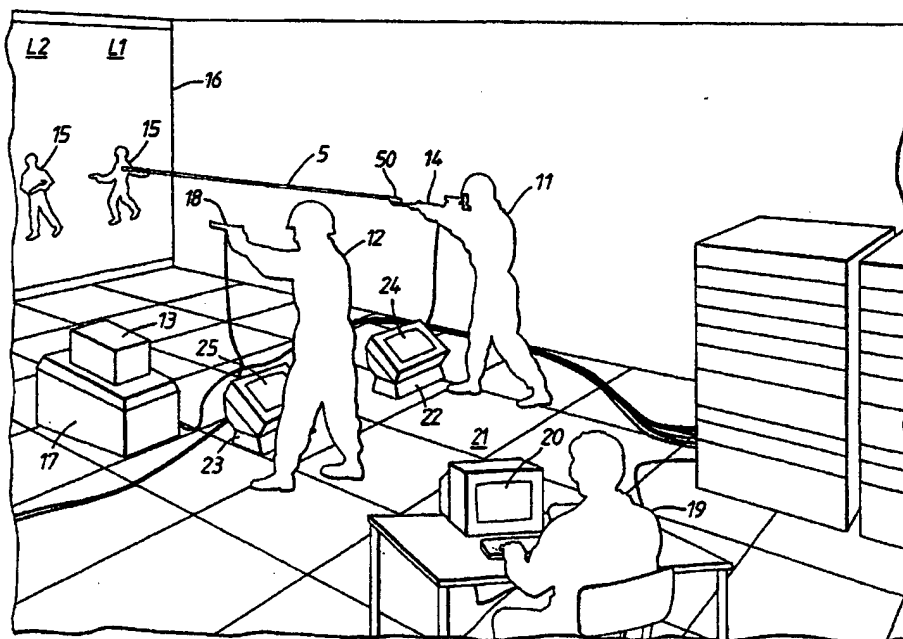
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(54) Title: TARGET ACQUISITION TRAINING APPARATUS AND METHOD OF TRAINING IN TARGET ACQUISITION

## (57) Abstract

Target acquisition training apparatus for use on a target acquisition range for training one or more aimers (11, 12) assembled on the range comprising projection means (17) for projecting onto a display medium (16) a target acquisition display comprising one or more target images (15), target acquisition means (14, 15) for the or each aimer (11, 12) for simulated acquisition of the target image (15) or a selected one of the target images (15) from a sighting position remote from the display medium (16), the or each target acquisition means (14, 15) comprising beam transmitting means (50, 51) for transmitting a beam (5) of radiation aligned with an aimpoint axis of the or each target acquisition means (14, 15) to produce on the display medium (16) a

localised radiation aimpoint zone or zones (10) representing the aimpoint of the or each target acquisition means (14, 15) on the display medium (16), a video camera (13) positioned to frame scan the display medium (16) and to generate from each frame scan video signals representing the aimpoint zone or zones (10) appearing on the display medium (16), and computing means (54) to select the camera video signals in each frame representing the aimpoint zone or zones (10) appearing on the display medium (16) and to generate therefrom aimpoint coordinates for the or each aimpoint zone (10) for aimpoint assessment of the one or more aimers (11, 12).



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Target Acquisition Training Apparatus  
and Method of Training in Target Acquisition

The present invention relates to target acquisition training apparatus for use on a target acquisition range for training one or more aimers assembled on the range and a method of training in target acquisition.

Two distinct requirements exist regarding ballistic weaponry training, namely, "how-to-shoot" and "when-to-shoot". The first option, "how-to-shoot" is usually taught on medium to long target ranges to achieve the highest accuracy possible and therefore requires the highest aimpoint measurement accuracy. The "when-to-shoot" option is, primarily, decision-based training, carried out on shorter target ranges, against rapidly moving targets, as might appear on a battlefield, in ambush and hostage situations and the like, where the prime purpose is to train the aimer to select targets correctly and to make a decision as to whether or not to shoot, while achieving satisfactory aimpoint accuracy depending on the circumstances presented to him when shooting. This option requires about one order of magnitude less in aimpoint measurement accuracy than the "how-to-shoot" option, because effective "when-to-shoot" training is achieved by a basic assessment of whether a relatively large target was hit or missed. The present invention can meet the requirements for both "how-to-shoot" and "when-to-shoot" training.

In conventional multi-arms trainers, using video or graphics sources for projection of target images on to a wall or screen, the weapon aimpoint is often determined by measuring the position of a near-infrared (IR) spot which is produced from a collimated source on the weapon

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and which is reflected from the wall or screen. The spot position is usually detected by a camera system viewing the wall or screen and linked to suitable hardware and/or software. The camera system can be calibrated to the visible projected image by prior measurement of a projected visible test pattern; an IR pass filter may then subsequently be used to cut out the visible wavelengths to prevent the camera system, after calibration, detecting the visible image, so that the IR spots may appear in a largely blank background, for ease of detection.

The conventional hardware/software used in such systems are typically based on a simple video level thresholding operation for spot detection and cannot unambiguously identify two separate IR spots appearing within any one video frame sampled by the camera spot measurement system. Thus, for N aimers, engaging targets on a single screen, as occurs in team training, if aimpoint tracking is to be achieved, aimpoint detection can take place at a maximum rate of only  $(1/N)$  times the normal video frame rate as the IR spots must be modulated so that only one at a time appears in any one camera frame.

In such a spot measurement system, aimpoint could be determined at the point of firing, by measuring the time of firing relative to time of aimpoint readouts before and after firing. The aimpoint coordinates before and after firing could then be used for interpolation based on trigger timing measurements to find the aimpoint coordinates at firing. However, the low tracking rate required for N aimers would, as N increases, make this increasingly subject to inaccuracy particularly if any aimpoint disturbance mechanism is implemented just after firing to simulate weapon recoil.

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An alternative way in such spot measurement systems is to ignore tracking of the aimpoint, and only to switch on the IR spots, for about one video frame time, on trigger pull, thus only measuring hitpoint. Again, this is a disadvantage should two or more aimers fire within the one camera frame time, since predetermined relative delays in switching on IR spots would be required unambiguously to identify aimpoint for the respective aimers.

According to a first aspect of the present invention there is provided target acquisition training apparatus for use on a target acquisition range for simultaneously training members of a group of aimers assembled on the range comprising projection means for projecting onto a display medium a target acquisition display comprising one or more target images, target acquisition means for each aimer for simulated acquisition of the target image or a selected one of the target images from a sighting position remote from the display medium, each target acquisition means comprising beam transmitting means for transmitting a beam of radiation aligned with an aimpoint axis of the target acquisition means to produce on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, a video camera positioned to frame scan the display medium and to generate from each frame scan video signals representing the aimpoint zones appearing on the display medium, and computing means to select the camera video signals in each frame representing the aimpoint zones appearing on the display medium and to generate therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

By target acquisition is meant the bringing of an

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aimpoint of a device such as a weapon or simulated weapon on to a target by an aimer of the device or his attempts thereat and may but not necessarily include the firing or simulated firing of the device at the target.

In an embodiment of the invention hereinafter to be described, the video camera is arranged to generate analogue video signals in each frame, an analogue to digital converter is provided to convert the analogue video signals to digitised video signals and the computing means comprises a digital computing means to select the digitised video signals in each frame representing the aimpoint zones appearing on the display medium and to generate therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

In an embodiment of the invention according to its first aspect, the analogue to digital converter is such as to convert the analogue video signals into digitised pixel video signals with each digitised pixel video signal having a discrete value identifying a grey level per pixel location. For this case, the digital computing means subjects the digitised pixel video signals in each frame representing the grey level value per pixel location to a centroiding process to determine the centre of each aimpoint zone to within a fraction of the central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone.

In an embodiment of the invention hereinafter to be described, the video camera is arranged to generate the analogue video signals in each frame by sequential scanning of interlaced scanning fields, the analogue to digital converter converts the analogue video signals field by field to digitised field signals and the digital

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computing means selects the digitised field signals in each field representing the aimpoint zones appearing on the display medium and generates therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers. The digital computing means preferably then includes a field store and the digitised field signals in each field are held for one field time in the field store to allow analysis of the digitised field signals.

In the embodiments of the invention according to its first aspect hereinafter to be described, the computing means is provided with algorithms to discriminate the aimpoint zones.

In a preferred embodiment of the invention, each beam transmitting means is arranged to transmit a beam of radiation modulated to provide a beam on-time, per camera field time, less than the camera field time to reduce movement induced aimpoint zone blur.

In an embodiment of the invention hereinafter to be described, each beam transmitting means transmits a beam of radiation such as to produce on the display medium a localised radiation aimpoint zone having an identifying characteristic different from that produced by each of the other beam transmitting means. The identifying characteristic of the zone may, for example, be its shape or its intensity.

According to a second aspect of the present invention there is provided target acquisition training apparatus for use on a target acquisition range for training an aimer assembled on the range comprising projection means for projecting onto a display medium a target acquisition

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display comprising a target image, target acquisition means for the aimer for simulated acquisition of the target image from a sighting position remote from the display medium, the target acquisition means comprising beam transmitting means for transmitting a beam of radiation aligned with an aimpoint axis of the target acquisition means to produce on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, a video camera positioned to frame scan the display medium and to generate from each frame scan an analogue video signal or signals representing the aimpoint zone appearing on the display medium, an analogue to digital converter which converts the analogue video signal or signals in to a digitised pixel video signal or signals each having a discrete value identifying a grey level per pixel location, and digital computing means to select the digitised pixel video signal or signals in each frame representing the aimpoint zone appearing on the display medium and to subject the digitised pixel video signal or signals to a centroiding process to determine the centre of the aimpoint zone to within a fraction of the central pixel within the aimpoint zone to provide aimpoint sub-pixel centroid coordinates for the aimpoint zone for aimpoint assessment of the aimer.

In an embodiment of the invention hereinafter to be described, the computing means includes a store to store in projected image coordinates one or more target outlines for each frame, and the aimpoint coordinates of each aimpoint zone are compared with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of each aimer.



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In an embodiment of the invention according to its first aspect hereinafter to be described, the computing means generates the aimpoint coordinates for each aimpoint zone in camera coordinates, the aimpoint camera coordinates of the aimpoint zones are arranged to be compared with reference camera coordinates stored in the computing means which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium by the projection means at predetermined projected image coordinates, on the basis of such comparison the aimpoint camera coordinates of the aimpoint zones are converted in to aimpoint projected image coordinates, and the aimpoint projected image coordinates of each aimpoint zone are compared with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimers.

In an embodiment of the invention according to its second aspect, the aimpoint sub-pixel centroid coordinates calculated for the aimpoint zone are in camera coordinates, the aimpoint camera coordinates of the aimpoint zone are arranged to be compared with reference camera coordinates stored in the computing means which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium by the projection means at predetermined projected image coordinates, on the basis of such comparison the aimpoint camera coordinates of the aimpoint zone are converted into aimpoint projected image coordinates, and the aimpoint projected image coordinates of the aimpoint zone are compared with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimer.

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The beam of radiation producing the localised radiation aimpoint zone is preferably a beam of infrared radiation which may take the form of laser radiation.

In an embodiment of the invention hereinafter to be described, the video camera is a monochrome CCD video camera sensitive to visible and infrared radiation and means are provided to interpose an infrared pass filter between the video camera and the display medium whereby the video camera generates only or substantially only video signals representing the aimpoint zones appearing on the display medium. The video camera integration period is preferably made less than the camera's field time to reduce the adverse effects of ambient infrared background lighting.

The projector is preferably in the form of a video projector and may be positioned centrally with respect to the screen and the video camera may conveniently be mounted on the video projector.

In the embodiments of the invention hereinafter to be described, each target acquisition means is a weapon or simulated weapon and the beam transmitting means is mounted on the weapon to represent on the display medium the aimpoint of the weapon.

According to a third aspect of the present invention there is provided a method of aimpoint assessment in simultaneously training members of a group of aimers in target acquisition on a target acquisition range comprising the steps of projecting onto a display medium a target acquisition display comprising one or more target images, arranging for each aimer to simulate acquisition of the target image or a selected one of the

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target images from a sighting position remote from the display medium using target acquisition means which comprises beam transmitting means which transmits a beam of radiation aligned with an aimpoint axis of the target acquisition means and produces on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, frame scanning the display medium using a video camera, generating from each frame scan video signals representing the aimpoint zones appearing on the display medium, selecting the video signals in each frame representing the aimpoint zones appearing on the display medium and generating therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

In an embodiment of the invention according to its third aspect, the video signals in each frame are arranged to be digitised pixel video signals each having a discrete value identifying a grey level per pixel location, and the digitised pixel video signals in each frame representing the aimpoint zones appearing on the display medium are selected and subjected to a centroiding process to determine the centre of each aimpoint zone to within a fraction of the central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone.

In an embodiment of the invention according to its third aspect, the projected display is frame scanned by sequential scanning of interlaced scanning fields, the digitised pixel video signals are generated field by field, and the digitised pixel video signals in each field representing the aimpoint zones appearing on the display medium are selected and subjected to a centroiding process to determine the centre of each

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aimpoint zone to within a fraction of the central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone. The digitised pixel video signals in each field may be held for one field time to allow analysis thereof.

In the embodiments of the invention according to its third aspect, means are provided to discriminate the aimpoint zones.

In an embodiment of the invention according to its third aspect, each beam transmitting means transmits a beam of radiation such as to produce on the display medium a localised radiation aimpoint zone having an identifying characteristic different from that produced by each of the other beam transmitting means. The identifying characteristic of the zone may, for example, be its shape or its intensity.

According to a fourth aspect of the present invention there is provided a method of aimpoint assessment in training an aimer in target acquisition on a target acquisition range comprising the steps of projecting onto a display medium a target acquisition display comprising a target image, arranging for the aimer to simulate acquisition of the target image from a sighting position remote from the display medium using a target acquisition means which comprises a beam transmitting means which transmits a beam of radiation aligned with an aimpoint axis of the target acquisition means and produces on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, frame scanning the display medium using a video camera, generating from each frame scan a digitised pixel video signal or signals each having a

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discrete value identifying a grey level per pixel location, selecting the digitised pixel video signal or signals in each frame representing the aimpoint zone appearing on the display medium and subjecting the digitised pixel video signal or signals to a centroiding process to determine the centre of the aimpoint zone to within a fraction of the central pixel within the aimpoint zone to provide aimpoint sub-pixel centroid coordinates for the aimpoint zone for aimpoint assessment of the aimer.

In an embodiment of the invention according to its third and fourth aspects, one or more target outlines are stored for each frame in projected image coordinates, and the aimpoint coordinates of each aimpoint zone are compared with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of each aimer.

In an embodiment of the invention according to its third aspect, the aimpoint coordinates are generated in camera coordinates, the aimpoint camera coordinates of the aimpoint zones are compared with reference camera coordinates which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium at predetermined projected image coordinates, the aimpoint camera coordinates of the aimpoint zones are converted in to projected image coordinates on the basis of such comparison, and the aimpoint projected image coordinates of each aimpoint zone are compared with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimers.

In an embodiment of the invention according to its fourth

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aspect, the aimpoint sub-pixel centroid coordinates of the aimpoint zone are arranged to be in camera coordinates, the aimpoint camera coordinates of the aimpoint zone are compared with reference camera coordinates which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium at predetermined projected image coordinates, the aimpoint camera coordinates of the aimpoint zone are converted into projected image coordinates on the basis of such comparison, and the aimpoint projected image coordinates of the aimpoint zone are compared with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimer.

In an embodiment of the invention according to both its third and fourth aspects, each beam transmitting means transmits a beam of infrared radiation which may take the form of infrared laser radiation.

In an embodiment of the invention according to both its third and fourth aspects, the reference zones are arranged to be projected onto the display medium prior to projection of the target acquisition display thereon, the display medium is frame scanned with the video camera and digitised pixel video signals representing the reference zones appearing on the display medium and each having a discrete value identifying a grey level per pixel location generated therefrom, and the digitised pixel video signals representing the reference zones appearing on the display medium are selected and subjected to a centroiding process to determine the centre of the reference zones to within a fraction of the central pixel within the reference zones to provide sub-pixel centroid coordinates for each reference zone.

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Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig 1 is a schematic perspective view of part of a weapon-fire training range embodying target acquisition training apparatus according to the invention

Fig 2 is an enlarged view of a part of the screen forming part of the target acquisition training apparatus according to the invention illustrated in Fig 1

Fig 3 is a block schematic diagram of the range illustrated in Fig 1 showing sub-assemblies of the target acquisition training apparatus according to the invention and their interconnections

Fig 4 is a flow chart illustrating a calibration procedure for the target acquisition training apparatus according to the invention

Fig 5 is a flow chart illustrating how aimpoint assessment of an aimer is achieved in an embodiment of the target acquisition training apparatus according to the invention

Fig 6 is a block schematic diagram of a single sensor/single processor forming part of the computing means for use in the target acquisition training apparatus illustrated in Figs 1 and 3

Fig 7 is a schematic block diagram showing in more detail the analogue to digital, digital to analogue and man-machine interface modules of the computing means illustrated in Fig 6

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Fig 8 is a block schematic diagram of the transputer processor module of the computing means illustrated in Fig 6 and

Fig 9 is a block schematic diagram of a multi-sensor/multi-processor system forming the computing means of the target acquisition training apparatus according to the invention and based on four single sensor/single processors described with reference to Figs 6 to 8

Referring first to Fig 1, the weapon fire training range shown is an indoor range for use by four marksmen, only two of which are schematically illustrated and indicated by reference numerals 11 and 12. As will be seen, the first marksman 11 occupies an end lane L1 and is provided with a simulated weapon 14 which he directs at target images 15 projected on to a screen 16 by a video projector assembly 17. The projector 17 provides for full coverage of the screen 16 and presents target images 15 for use in training all four marksmen in target acquisition. Training of the four marksmen in this embodiment takes place simultaneously.

The second marksman 12 is provided with a simulated weapon 18 for use against the target images 15 displayed on the screen 16 by the projector 17. It is to be noted that the target acquisition training of the two marksmen 11 and 12 is provided in respect of weapons of different type and the other marksmen not shown can if desired be provided with simulated weapons of the same or other types.

In any event, each simulated weapon has mounted thereon an infrared laser diode which transmits a collimated infrared laser beam which converges with the optical



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sight of the weapon at a predetermined range of the marksman from the screen 16. By way of example, the weapon 14 used by the first marksman 11 is shown with an infrared laser diode 50 mounted thereon which transmits an infrared laser beam 5.

With the above in mind, when the marksmen 11 and 12 aim their weapons 14 and 18 at the screen 16 from the predetermined range, each infrared laser diode produces on the screen 16 an aimpoint spot 10 coincident with the aimpoint of the weapon, as illustrated in Fig 2. The aimpoint spots 10 produced on the screen 16 by the laser diodes of each weapon 14 and 18 in this manner may, as illustrated in Fig 2, be of different identifying characteristics, such as for example of different shapes or intensities.

Referring back to Fig 1, the training range is placed under the control of a controller 19 who is provided with target assessment displays on a monitor screen 20 of a master console sub-assembly 21. In addition, each of the marksmen 11 and 12 is provided with floor box sub-assemblies 22 and 23 which provide on monitors 24 and 25 information as to their own target acquisition performance.

A video camera 13 is mounted on the video projector 17 and is arranged to have a field of view of the screen 16 corresponding to the full field projected by the video projector 17.

Each of the floor box sub-assemblies 22 and 23 and each of the other two floor box sub-assemblies include a lane microprocessor for processing lane information applied to it and lane monitor screens 24 and 25 for use by the

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marksmen.

Referring now to Fig 3, the sub-assemblies of the target acquisition training apparatus shown in Fig 1 are illustrated in block diagram form and include the screen 16, the video projector 17, the video camera 13 mounted thereon, simulated weapons 14 and 18 together with two further simulated weapons 34 and 35 for use by marksmen in the other two lanes of the range, floor box sub-assemblies 22 and 23, including the lane monitors 24 and 25 and lane microprocessors 36 and 37, together with two further floor box sub-assemblies 38 and 39 including further lane monitors 40 and 41 and further lane microprocessors 42 and 43 and the master control sub-assembly 21.

The video camera 13 is shown to comprise a camera box 44 mounted on the projector 17, a CCD sensor array device 45, a camera lens body 46, a front window 47 and interposed between the window 47 and the lens body 46 an infrared pass filter 48 movable into and out of the field of view of the camera 13 under the control of a filter selection motor 49.

The weapons 14, 18, 34 and 35 are provided with infrared laser diodes 50, 51, 52 and 53, which are arranged to transmit collimated infrared laser beams, each of which is set to converge with the optical sight of the weapon at a predetermined range of the marksman from the screen 16.

A camera output path 80 feeds the video signal from the camera 13 to a multi-sensor/multi-processor system 54 which determines the tracking coordinates of each aimpoint IR spot 10 on the screen 16. The tracking

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coordinates are fed to the master console 21 along a multi-sensor/multi-processor system output path 81 and then to a video/graphics display control system 55 which controls the projection of video images from the projector 17 along a master console output path 82.

The infrared pass filter 48 is, during tracking of the aimpoint IR spots 10 on the screen 16, automatically positioned in the field of view of the video camera 13, specifically to prevent the camera 13 detecting the visible image projected by the projector 17 as this would interfere with the aimpoint IR spot detection process.

In order that the aimpoint IR spot position can be related to the projected visible image a calibration procedure of the type according to the flow chart illustrated in Fig 4 is performed on system start-up.

At step 100 a grid of visible white spots, with predefined projection image coordinates, is projected on to the screen 16. The infrared pass filter 48 is removed at step 101 and the video camera 13 samples the calibration spots at step 102 and generates signals representing the calibration spots appearing on the screen 16 which are fed to the processor system 54 along the camera output path 80. The processor system 54 determines at step 103 the centroids of the calibration spots in camera coordinates and stores them in memory at step 104. The infrared pass filter 48 is then repositioned in the field of view of the camera 13 at step 105 so that training can commence.

The camera coordinate calibration centroids can then be related directly back to each projected image, where the target positions and shapes have been stored in memory

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for each image frame displayed. Therefore, after calibration, the position of any aimpoint IR spot 10 is measured in camera coordinates, which, via the calibration grid mapping, are then translated into image coordinates, since the calibration grid was, firstly, defined in image coordinates. Then, since the target positions and sizes, in image coordinates, are stored for each frame displayed, in the processor system memory, the coordinates of the aimpoint IR spots 10 with respect to the target images can be determined, and an assessment made of whether the target was hit or missed, on firing of the weapon and, if required, the degree of accuracy attained.

While the target acquisition training apparatus hereinbefore described is shown being used for training a plurality of aimers, it will be appreciated that the apparatus is equally suitable for training an individual assembled on the range.

The flow chart set out in Fig 5 illustrates the relationship between the camera coordinate calibration centroids, the stored target outlines and an aimpoint spot 10 tracked for aimpoint assessment of an aimer in training.

At steps 104 and 110 respectively, the centroids of the calibration spots in camera coordinates and the projected image coordinates of a target image outline in each frame are stored in memory. At step 150, a target acquisition display comprising the target image 15 is projected onto the screen 16. At step 151 an aimer simulates acquisition of the target image 15. At step 152 the video camera 13 samples the screen 16 and generates along the camera output path 80 for each frame scan video

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signals representing the aimpoint spot 10 appearing on the screen 16. The processor system 54 processes the camera video signals received along output path 80 and determines the camera coordinates of the aimpoint spot 10 in each frame at step 153. The camera coordinates of the aimpoint spot 10 are then compared with the stored camera coordinates of the calibration spots at step 154 and on the basis of such comparison converted into projected image coordinates. The projected image coordinates of the aimpoint spot 10 are then compared with the stored projected image coordinates of the target outline for corresponding frames at step 155 to enable aimpoint assessment of the aimer to take place at step 156.

Although the flow chart in Fig 5 refers to a single target image being projected onto the screen 16 for a single aimer, it will be appreciated that the flow chart is equally applicable for the case of simultaneous training of a group of aimers using one or more projected target images.

A multi-sensor/multi-processor architecture as hereinafter to be described with reference to Fig 9 is required for processing the aimpoint information when two or more systems are combined, to allow many aimers to be trained, simultaneously, over multiple projection screens. The architecture for a single-sensor/single processor system will however first be described in detail with reference to Figs 6 to 8.

Referring first to Fig 6, the single sensor/single processor system comprises a video A/D module 56, a front end processing module 57, which performs a segmentation operation in real-time, and a transputer processor module 58, which performs further data dependent processing. An

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RGB display monitor 61 is used for display purposes. Due to the design, the system may be expanded simply by adding further processor boards and adapting the software to use them and additional sensors may be integrated into the system with the addition of suitable A/D and front end processing modules as hereinafter to be described.

The modules of the processor architecture of Fig 6, and their interactions will now be described with reference to Fig 7.

Referring to Fig 7, the video A/D module 56 converts a PAL video signal into a 512 x 512 pixel image of 8 bit data, and is arranged to cope with both interlaced and non-interlaced formats. It also provides the timing signals for the digitised data, namely; pixel clock, line synch, frame synch, valid data indicator, odd/even field indicator, pixel number and line number.

Interlaced video comprises two half-frame fields which are distinguishable by the relationship of the line and frame timing, and the odd/even signal indicates the current field in this case. Active image data is indicated by the valid data signal.

Circuits 62, 63, 64 and 65 for generating the above timing signals are implemented on a first Xilinx PGA 66 and the outputs from the circuits are used by a D/A module 67 to create a display and by the front end processing module 57 which performs a segmentation operation.

The front end processing module 57 is required to segment the real-time image data in order to reduce the amount of information to be processed by the transputer module 58.

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A block diagram of the transputer based processor is shown in Figure 8. As the figure shows, the transputer 58 has access not only to standard areas of RAM and EPROM, but also has an area of video RAM (VRAM) mapped into its memory space. The VRAM contains two distinct fields of data, each 512 x 256 pixels in size. This allows processing to occur on one field while the other is being written to with new image data. This image data, coming from the front-end processing module 57, is clocked in a serial fashion into a register on the VRAM. The transfer can occur simultaneously with the read/write operations of the processor, apart from the loss of one processor cycle per video line (512 pixels). A DMA control block 71 supervises the transfers.

A new field arrives every 20ms (for 50Hz operation) and its arrival is signalled to the transputer via an event controller 72. The transputer can then switch attention to the newly arrived field allowing the next field to be transferred to the other section of VRAM.

Transputer serial links 73 are available for communication with other processors and are taken off the board on a standard connector.

The hardware hereinbefore described constitutes a single-sensor/single-processor image processing system. It is, however, designed in a modular manner with the result that conversion to a multi-sensor/multi-processor system can readily be made. Additional processor boards can be added by simply slotting them into the rack, connecting their serial links in the desired manner and altering the software to utilise the extra processing power. All of the processors will therefore have access to all of the image data. This allows data dependent algorithms to be

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run on particular processors without the need to transfer image data through the serial links. This not only increases the efficiency of the system but greatly improves its flexibility.

A multi-sensor/multi-processor system can therefore be created by simply adding suitable combinations of sensor processing systems to the hardware described with reference to Figs 6 to 8 and allowing the transputers to communicate via their serial links 73 as illustrated in Fig 9.

In accordance with the present invention, sub-pixel resolution may be employed to determine the centroids of the calibration and aimpoint spots to within a fraction of the central pixel within each spot. Sub-pixel resolution essentially involves generating a pixel image by digitising the video signal or signals generated by the video camera 13 on frame scanning the screen 16 into a signal or signals each having a discrete value identifying a single grey level per pixel location and representing the intensities in the image detected by the video camera 13, for example an IR or visible spot. A simple centroiding technique is then used to find the centre of the light distribution to within a certain fraction of the central pixel of, in this example, the spot, in both x and y axes. The simplest centroiding techniques assume a distinguishable fall-off in light intensity on pixels immediately adjacent to the central, that is to say, the brightest pixel. The system is therefore engineered to ensure that this, in fact, is the case if it is to work accurately - eg IR spots need to be modulated so that they are switched on for significantly less than one camera field time, in order to reduce movement-induced blur, which would otherwise distort the



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sub-pixel resolution process.

When sub-pixel resolution techniques are applied to the calibration method, the calibration method is highly accurate since the calibration spot centroids are measured to sub-pixel accuracy, and can be performed, simultaneously, up to the edges of the projection screen area. Other systems can only maintain relative accuracies over small portions of such a screen ie they cannot maintain absolute accuracy over most of the screen, because they do not use such an advanced calibration system. For such systems, marksmanship relative accuracy may be achieved over any small portion of the screen, but weapon re-zeroing is required for use on any other part of the screen, because the absolute accuracy is not preserved. The calibration method according to the present invention thus has a distinct advantage, in preserving the absolute accuracy over most of the screen.

Furthermore, the application of sub-pixel resolution techniques to both detection of the aimpoint spot centroids, and the calibration spot centroids, gives a factor of approximately 10 times increase in angular absolute accuracy over that produced by a single camera system measuring to 1 pixel accuracy.

Sub-pixel accuracy depends on calculating an intensity-weighted centroid, based on the stored grey levels per spot. Pixel jitter timing artefacts are minimised by stripping off the CCD camera video sync signals, and restarting the pixel sampling clock for the video field store, on the relevant rising edge of the sync signal. The field store pixel clock thus operates in a phase-locked loop mode.

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Therefore, there has been constructed in accordance with the present invention a wide angle camera measurement system, using sub-pixel resolution techniques, capable of producing marksmanship-type measurement accuracies, over a wide-screen, using a conventional 512 pixels/line resolution field store, whereas, previously this would have required multiple cameras and field stores, to achieve the same measurement accuracy.

Although sub-pixel resolution may be attempted by a direct digitisation of the video signal using an external digitisation board, with an accurate on-board clock, in a preferred embodiment of the invention a more accurate result is achieved by using the internal camera pixel clock supplied to the external digitisation board.

The target acquisition training apparatus described provides sufficient accuracy for "when-to-shoot" and "how-to-shoot" training, with particular relevance to team training, where the effectiveness of the system is greatly enhanced by the use of appropriate hardware and software, for automatic aimpoint detection and tracking. With target acquisition training apparatus according to the invention, multiple IR spots representing aimpoint from a plurality of weapons, as experienced in team training, may be switched on for continuous illumination of the screen or wall, and may be tracked continuously at video frame rates, where the aimers are each engaging separate targets. The higher tracking rate consistently inherent in the apparatus, compared to conventional apparatus, provides not only better tracking information, but also greater hitpoint assessment accuracy, since firstly, interpolation between aimpoint updates, at  $(1/N)$  times video rates for N aimers, is not required, where separate targets/aimer are engaged, and secondly,

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multiple aimers may all fire simultaneously within one video frame time without relative aimpoint measurement delays between firers being inherently required in the system.

If necessary, a means of discriminating between aimers on the basis of laser spot shape, or intensity, may be implemented. This means that if several aimers engage one target at the same time, the apparatus hereinbefore described may still correctly identify the ownership of the IR spots, without having to modulate them in sequence over successive video frames. In these circumstances also, the tracking rate advantage is preserved over conventional systems.

The identification of IR spots on the basis of either shape or intensity may be implemented by converting the analogue video signal per field to a digitised signal, giving for example, 256 grey levels per pixel location. The digitised camera field is held for 1 field time, after digitisation, in a field store, to allow analysis. Since the video grey levels are stored for 1 field time, this ultimately allows complex processing such as discrimination on the basis of spot shape or intensity, whereas a simple thresholding of the video signal could be more limited in discrimination capability, particularly as regards overlapping spots, or for sub-pixel resolution. With access to the digitised grey levels per pixel, however, more complex processing algorithms can be used to achieve separation and identification of overlapping spots, or alternatively sub-pixel resolution, on single laser spots.

It is also to be noted that to assist in spot tracking and identification, the weapon-mounted IR laser diode

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sources are modulated so that they are switched on in each camera field time, for much less than the actual field time, in order to reduce movement-induced blur which would otherwise distort spot shape and reduce intensity. This feature can allow, therefore, very much higher tracking rates, while still preserving IR spot shape and intensity, than would be achieved with simple unmodulated cw laser sources.

In one previously mentioned implementation of the conventional system, with the IR spot switched on briefly at trigger pull only, there is no tracking facility, and thus ignores an essential part of training. The apparatus according to the invention can, however, track the IR spot as the aimer slews it on to the target and attempts to track it; the storage and replay of such aimpoint information thus provides valuable feedback on weapon handling, when subsequently overlaid on the projected image sequence used. The generally higher tracking rate of the apparatus according to the invention, for multiple aimers, is highly beneficial as regards the accuracy of tracking, and, hence, produces improved training capability.

Various recorded or computer generated scenarios may be projected by a video or graphic projector on to a wall or screen to multiple aimers, and the apparatus according to the invention using the digitised video output of the camera system viewing the wall or screen determines the aimpoint coordinates, of the IR spots, produced by weapon-mounted IR laser sources. The accuracy achieved by digitising the video signal from the camera 13, viewing the wall or screen to determine the IR spot aimpoints, can easily be arranged to be satisfactory for both "when-to-shoot" (hit or miss) and "how-to-shoot"

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training.

The target sizes and locations, for each frame of the video imagery, will be previously determined by using a target box, the coordinates and size of which are stored in memory along with the relevant video frame number. The aimpoint with respect to the target box coordinates can then be used to determine if the shot hit or missed the target and, if required, the degree of accuracy of a hit or miss.

To assist in attaining improved continuous aimpoint identification and tracking, in an embodiment of the target acquisition training apparatus according to the invention when a laser spot has been uniquely identified, by pulsing all the lasers in sequence beforehand, a numbered tracking gate or box is placed around each laser spot detected on the screen by the target acquisition training apparatus. When the laser spots are not coincident on the same target eg in marksmanship mode, where each aimer has targets displayed in his individual marksmanship lane, then all the laser spots may be uniquely identified, and continuously tracked, from one camera field time to the next, without having to reduce the tracking rate below the camera field rate for multiple lasers, because the unique identification of each laser spot is preserved by the target acquisition training apparatus.

Additionally, the target acquisition training apparatus provides very much greater flexibility in tracking the laser spots, because no division of the screen into discrete tracking zones per aimer is required. This is because the apparatus can track any laser spot uniquely over the complete video screen at full camera field

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rates. It is only necessary to reduce the tracking rate when the tracking boxes around the laser spots overlap, for example, when 2 or more lasers are aimed in the vicinity of 1 target, in scenario mode. The use of the target acquisition training apparatus according to the invention, therefore, provides useful gains in overall tracking rate and, therefore, accuracies.

Conventional systems will generally, either use modulation of the lasers over several camera fields, therefore reducing tracking rates, or will sub-divide the screen into different zones, 1 for each marksmanship lane, so that a laser spot can only be uniquely tracked at full camera field rates, within its own marksmanship lane. Such systems, are, thus generally, less flexible and accurate than the present invention.

In summary, target acquisition training apparatus in accordance with the invention provides for the following uses, namely:

- (i) Use of the apparatus for basic "when-to-shoot", hit or miss, training, where the apparatus gives improved aimpoint identification and tracking over conventional systems for multiple aimers engaging targets displayed on a wide-screen or wall.
- (ii) Use of the apparatus for "how-to-shoot" training.
- (iii) Use of sub-pixel resolution for increased aimpoint accuracy, for example where sub-pixel resolution techniques are used to determine the centroids of the calibration and aimpoint spots

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then an increase in angular absolute accuracy of a factor of 10 times is achieved over that produced by a single camera system measuring to 1 pixel accuracy.

In addition, the apparatus according to the invention may have the following features:

- (1) A high resolution video projector positioned centrally with respect to the projection screen wall.
- (2) A visible and IR sensitive, monochrome, CCD video camera, for example positioned on the video projector for viewing the projection wall or screen to detect IR spots from weapon-mounted collimated laser sources.
- (3) An analogue to digital conversion board, to digitise the video output of the CCD camera, with a frame store to hold the digitised grey levels for 1 field time.
- (4) Hardware/software - implemented IR spot identification algorithms to analyze the stored digitised video signals and identify the IR spots.
- (5) Hardware/software to automatically track the identified IR spots and store the tracking coordinates.
- (6) Calibration of the CCD video camera to the visible projected image, by projection and analysis of a test pattern composed of discrete pre-defined highlighted coordinates eg a regular grid of white

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spots on a black background.

- (7) A mechanism to position an IR pass filter in front of the camera lens, after calibration to the projected visible image, in order to provide a largely blank background to assist in detecting the IR spots.
- (8) Selection of a camera integration period, during IR spot tracking, of less than the normal 20ms (for 50Hz operation) camera field time, to further reduce the effects of ambient IR background lighting.
- (9) Use of a modulation input to the IR laser sources, to provide a laser on-time, per camera field time, of much less than 20ms (for 50Hz operation), for the purpose of reducing movement-induced IR spot blur.
- (10) Use of suitable hardware and/or software to synchronise the laser on-time per field, with the reduced camera integration period per field.
- (11) Use of a genlock input on the centrally-mounted camera to synchronise the camera and video projector field timings, so that the detected aimpoints per camera field can be matched to an exact displayed video image.
- (12) Use of pre-recorded, or computer generated, video sequences, for scenario training, where the target or targets in each video frame have been pre-designated with a stored target box size and location, in order to determine hit or miss on firing.



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- (13) Use of a lane processor per weapon, to control weapon functions eg measure trigger timing and control laser modulation and to control information flow to and from the master console.
- (14) Use of a master console to control the entire system, and assist the controller in monitoring practices, both individual and group.
- (15) Possibility of expansion to more complex digital video processing to identify IR spots on the basis of shape or intensity, to allow identification of overlapping spots, and to provide sub-pixel resolution.
- (16) Use of pixel clock output, directly from the camera, to improve synchronisation between the camera analogue output and the analogue to digital circuitry, thus providing improved aimpoint accuracy, with possibly a direct extension of this to sub-pixel resolution techniques.

It will be appreciated by those versed in the art that the target acquisition training apparatus according to the present invention can be used singularly or alternatively be combined with further ones of the target acquisition training apparatus to allow many aimers to be trained simultaneously over multiple projection screens.

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CLAIMS

1. Target acquisition training apparatus for use on a target acquisition range for simultaneously training members of a group of aimers assembled on the range comprising projection means for projecting onto a display medium a target acquisition display comprising one or more target images, target acquisition means for each aimer for simulated acquisition of the target image or a selected one of the target images from a sighting position remote from the display medium, each target acquisition means comprising beam transmitting means for transmitting a beam of radiation aligned with an aimpoint axis of the target acquisition means to produce on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, a video camera positioned to frame scan the display medium and to generate from each frame scan video signals representing the aimpoint zones appearing on the display medium, and computing means to select the camera video signals in each frame representing the aimpoint zones appearing on the display medium and to generate therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

2. Apparatus according to claim 1, wherein the video camera is arranged to generate analogue video signals in each frame, wherein an analogue to digital converter is provided to convert the analogue video signals to digitised video signals and wherein the computing means comprises a digital computing means to select the digitised video signals in each frame representing the aimpoint zones appearing on the display medium and to generate therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

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3. Apparatus according to claim 2, wherein the analogue to digital converter is such as to convert the analogue video signals into digitised pixel video signals with each digitised pixel video signal having a discrete value identifying a grey level per pixel location.

4. Apparatus according to claim 3, wherein the digital computing means subjects the digitised pixel video signals in each frame representing the grey level value per pixel location to a centroiding process to determine the centre of each aimpoint zone to within a fraction of the central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone.

5. Apparatus according to any one of claims 2 to 4, wherein the video camera is arranged to generate the analogue video signals in each frame by sequential scanning of interlaced scanning fields, wherein the analogue to digital converter converts the analogue video signals field by field to digitised field signals and wherein the digital computing means selects the digitised field signals in each field representing the aimpoint zones appearing on the display medium and generates therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

6. Apparatus according to claim 5, wherein the digital computing means includes a field store and wherein the digitised field signals in each field are held for one field time in the field store to allow analysis of the digitised field signals.

7. Apparatus according to any one of the preceding claims, wherein the computing means is provided with

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algorithms to discriminate the aimpoint zones.

8. Apparatus according to any one of the preceding claims, wherein each beam transmitting means is arranged to transmit a beam of radiation modulated to provide a beam on-time, per camera field time, less than the camera field time to reduce movement induced aimpoint zone blur.

9. Apparatus according to any one of the preceding claims, wherein each beam transmitting means transmits a beam of radiation such as to produce on the display medium a localised radiation aimpoint zone having an identifying characteristic different from that produced by each of the other beam transmitting means.

10. Apparatus according to claim 9, wherein the identifying characteristic of the zone is its shape.

11. Apparatus according to claim 9, wherein the identifying characteristic of the zone is its intensity.

12. Target acquisition training apparatus for use on a target acquisition range for training an aimer assembled on the range comprising projection means for projecting onto a display medium a target acquisition display comprising a target image, target acquisition means for the aimer for simulated acquisition of the target image from a sighting position remote from the display medium, the target acquisition means comprising beam transmitting means for transmitting a beam of radiation aligned with an aimpoint axis of the target acquisition means to produce on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, a video camera positioned to frame scan the

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display medium and to generate from each frame scan an analogue video signal or signals representing the aimpoint zone appearing on the display medium, an analogue to digital converter which converts the analogue video signal or signals in to a digitised pixel video signal or signals each having a discrete value identifying a grey level per pixel location, and digital computing means to select the digitised pixel video signal or signals in each frame representing the aimpoint zone appearing on the display medium and to subject the digitised pixel video signal or signals to a centroiding process to determine the centre of the aimpoint zone to within a fraction of the central pixel within the aimpoint zone to provide aimpoint sub-pixel centroid coordinates for the aimpoint zone for aimpoint assessment of the aimer.

13. Apparatus according to any one of the preceding claims, wherein the computing means includes a store to store in projected image coordinates one or more target outlines for each frame, and wherein the aimpoint coordinates of each aimpoint zone are compared with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of each aimer.

14. Apparatus according to claim 13 as appendent on claims 1 to 11, wherein the computing means generates the aimpoint coordinates for each aimpoint zone in camera coordinates, wherein the aimpoint camera coordinates of the aimpoint zones are arranged to be compared with reference camera coordinates stored in the computing means which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium by the projection means at predetermined projected

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image coordinates, wherein on the basis of such comparison the aimpoint camera coordinates of the aimpoint zones are converted in to aimpoint projected image coordinates, and wherein the aimpoint projected image coordinates of each aimpoint zone are compared with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimers.

15. Apparatus according to claim 13 as appendent on claim 12, wherein the aimpoint sub-pixel centroid coordinates calculated for the aimpoint zone are in camera coordinates, wherein the aimpoint camera coordinates of the aimpoint zone are arranged to be compared with reference camera coordinates stored in the computing means which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium by the projection means at predetermined projected image coordinates, wherein on the basis of such comparison the aimpoint camera coordinates of the aimpoint zone are converted into aimpoint projected image coordinates, and wherein the aimpoint projected image coordinates of the aimpoint zone are compared with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimer.

16. Apparatus according to any one of the preceding claims, wherein each beam transmitting means is arranged to transmit a beam of infrared radiation.

17. Apparatus according to any one of claims 1 to 15, wherein each beam transmitting means is arranged to transmit a beam of infrared laser radiation.

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18. Apparatus according to claim 16 or 17, wherein the video camera is a monochrome CCD video camera sensitive to visible and infrared radiation.

19. Apparatus according to claim 18, wherein means are provided to interpose an infrared pass filter between the video camera and the display medium whereby the video camera generates only or substantially only video signals representing the aimpoint zones appearing on the display medium.

20. Apparatus according to claim 19, wherein the video camera has an integration period which is less than the camera's field time to reduce the adverse effects of ambient infrared background lighting.

21. Apparatus according to any one of the preceding claims, wherein the projection means is a video projector.

22. Apparatus according to claim 21, wherein the video projector is positioned centrally with respect to the display medium.

23. Apparatus according to any one of the preceding claims, wherein the video camera is positioned centrally with respect to the display medium.

24. Apparatus according to claim 23 as appendent on claim 22, wherein the video camera is mounted on the video projector.

25. Apparatus according to any one of the preceding claims, wherein each target acquisition means includes a weapon or simulated weapon for each aimer and wherein the

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beam transmitting means is mounted on the weapon to represent on the display medium the aimpoint of the weapon.

26. A method of aimpoint assessment in simultaneously training members of a group of aimers in target acquisition on a target acquisition range comprising the steps of projecting onto a display medium a target acquisition display comprising one or more target images, arranging for each aimer to simulate acquisition of the target image or a selected one of the target images from a sighting position remote from the display medium using target acquisition means which comprises beam transmitting means which transmits a beam of radiation aligned with an aimpoint axis of the target acquisition means and produces on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, frame scanning the display medium using a video camera, generating from each frame scan video signals representing the aimpoint zones appearing on the display medium, selecting the video signals in each frame representing the aimpoint zones appearing on the display medium and generating therefrom aimpoint coordinates for each aimpoint zone for aimpoint assessment of the aimers.

27. Method according to claim 26, including the step of arranging for the video signals in each frame to be digitised pixel video signals each having a discrete value identifying a grey level per pixel location, selecting the digitised pixel video signals in each frame representing the aimpoint zones appearing on the display medium and subjecting the digitised pixel video signals in each frame to a centroiding process to determine the centre of each aimpoint zone to within a fraction of the



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central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone.

28. Method according to claim 27, including the steps of frame scanning the projected display by sequential scanning of interlaced scanning fields, generating the digitised pixel video signals field by field, selecting the digitised pixel video signals in each field representing the aimpoint zones appearing on the display medium and subjecting the digitised pixel video signals in each field to a centroiding process to determine the centre of each aimpoint zone to within a fraction of the central pixel within each aimpoint zone to provide aimpoint sub-pixel centroid coordinates for each aimpoint zone.

29. Method according to claim 28, including the step of holding the digitised pixel video signals in each field for one field time to allow analysis thereof.

30. Method according to any one of claims 26 to 29, including the step of providing means to discriminate the aimpoint zones.

31. Method according to any one of claims 26 to 30, including the step of arranging for each beam transmitting means to transmit a beam of radiation such as to produce on the display medium a localised radiation aimpoint zone having an identifying characteristic different from that produced by each of the other beam transmitting means.

32. Method according to claim 31, including the step of arranging for the identifying characteristic of

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the zone to be its shape.

33. Method according to claim 31, including the step of arranging for the identifying characteristic of the zone to be its intensity.

34. A method of aimpoint assessment in training an aimer in target acquisition on a target acquisition range comprising the steps of projecting onto a display medium a target acquisition display comprising a target image, arranging for the aimer to simulate acquisition of the target image from a sighting position remote from the display medium using a target acquisition means which comprises a beam transmitting means which transmits a beam of radiation aligned with an aimpoint axis of the target acquisition means and produces on the display medium a localised radiation aimpoint zone representing the aimpoint of the target acquisition means on the display medium, frame scanning the display medium using a video camera, generating from each frame scan a digitised pixel video signal or signals each having a discrete value identifying a grey level per pixel location, selecting the digitised pixel video signal or signals in each frame representing the aimpoint zone appearing on the display medium and subjecting the digitised pixel video signal or signals to a centroiding process to determine the centre of the aimpoint zone to within a fraction of the central pixel within the aimpoint zone to provide aimpoint sub-pixel centroid coordinates for the aimpoint zone for aimpoint assessment of the aimer.

35. Method according to any one of claims 26 to 34, including the step of storing in projected image coordinates one or more target outlines for each frame,

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and comparing the aimpoint coordinates of each aimpoint zone with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of each aimer.

36. Method according to claim 35 as appendent on any of claims 26 to 33, including the steps of generating the aimpoint coordinates in camera coordinates, comparing the aimpoint camera coordinates of the aimpoint zones with reference camera coordinates which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium at predetermined projected image coordinates, converting the aimpoint camera coordinates of the aimpoint zones in to projected image coordinates on the basis of such comparison, and comparing the aimpoint projected image coordinates of each aimpoint zone with the stored projected image coordinates of the target outline or a selected one of the target outlines for aimpoint assessment of the aimers.

37. Method according to claim 35 as appendent on claim 34, including the steps of arranging for the aimpoint sub-pixel centroid coordinates of the aimpoint zone to be in camera coordinates, comparing the aimpoint camera coordinates of the aimpoint zone with reference camera coordinates which are sub-pixel centroid coordinates of a plurality of reference zones projected onto the display medium at predetermined projected image coordinates, converting the aimpoint camera coordinates of the aimpoint zone into projected image coordinates on the basis of such comparison, and comparing the aimpoint projected image coordinates of the aimpoint zone with the projected image coordinates of the target outline or a selected one of the target outlines for aimpoint

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assessment of the aimer.

38. Method according to any one of claims 26 to 37, including the step of arranging for each beam transmitting means to transmit a beam of infrared radiation.

39. Method according to any one of claims 26 to 37, including the step of arranging for each beam transmitting means to transmit a beam of infrared laser radiation.

40. Method according to claim 36 or 37, including the steps of arranging for the reference zones to be projected onto the display medium prior to projection of the target acquisition display thereon, frame scanning the display medium with the video camera, generating from the frame scanning digitised pixel video signals representing the reference zones appearing on the display medium and each having a discrete value identifying a grey level per pixel location, selecting the digitised pixel video signals representing the reference zones appearing on the display medium and subjecting the digitised pixel video signals to a centroiding process to determine the centre of the reference zones to within a fraction of the central pixel within the reference zones to provide sub-pixel centroid coordinates for each reference zone.

41. Target acquisition training apparatus substantially as hereinbefore described with reference to the accompanying drawings.

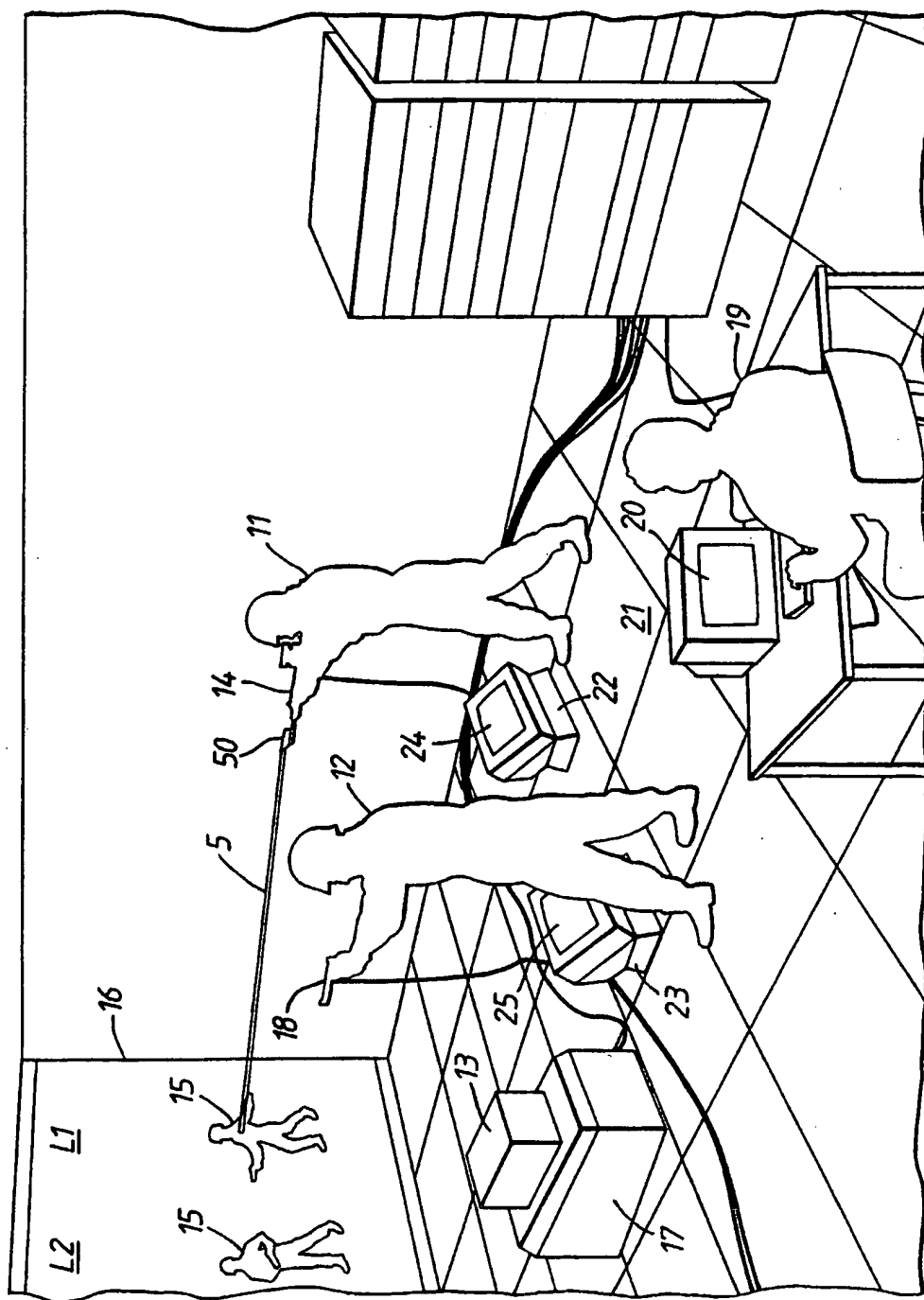
42. Method of training in target acquisition substantially as hereinbefore described with reference to

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the accompanying drawings.

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Fig.1.



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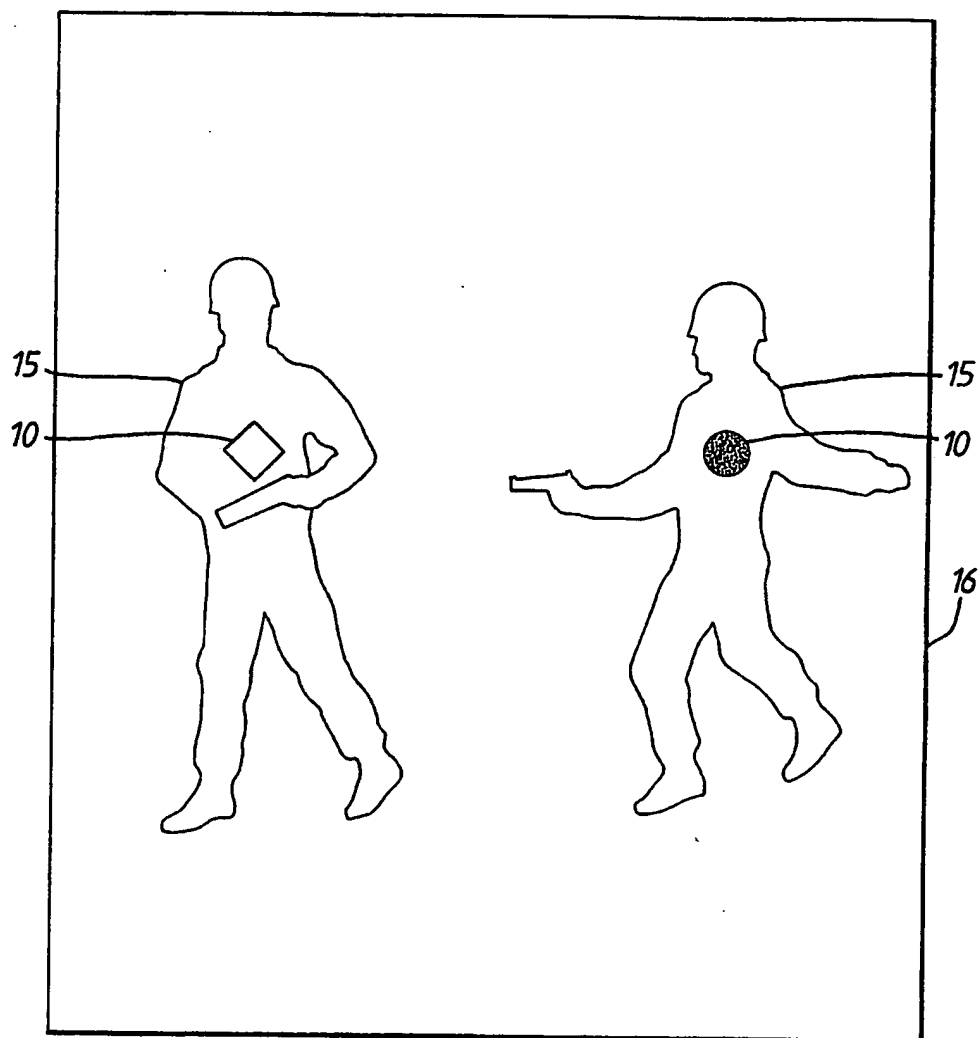
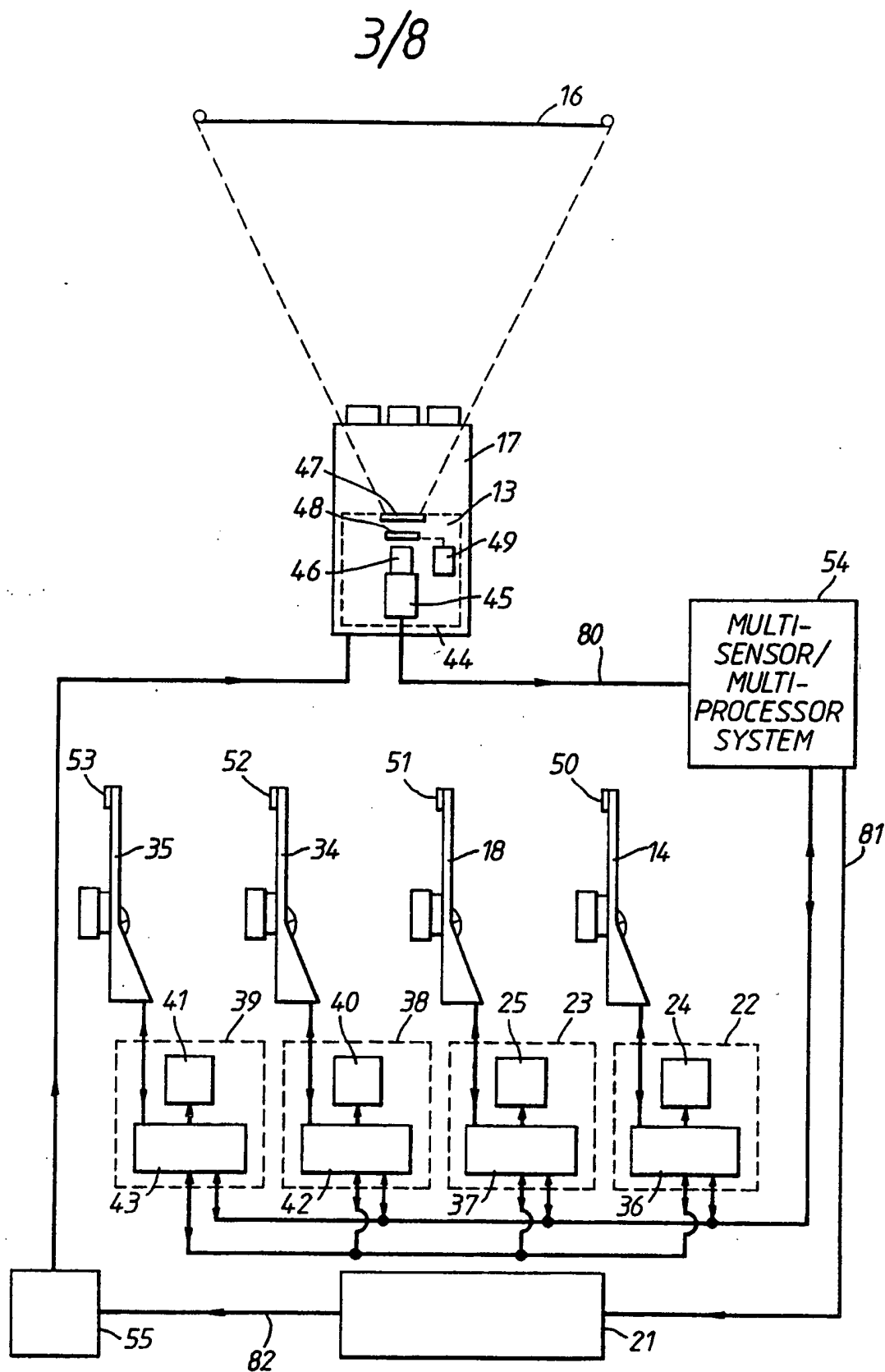


Fig.2





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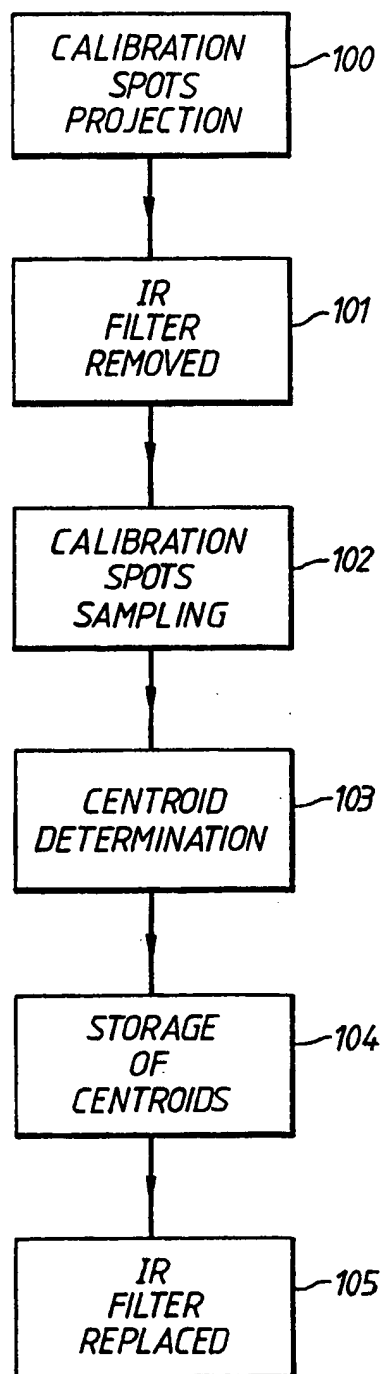


Fig.4

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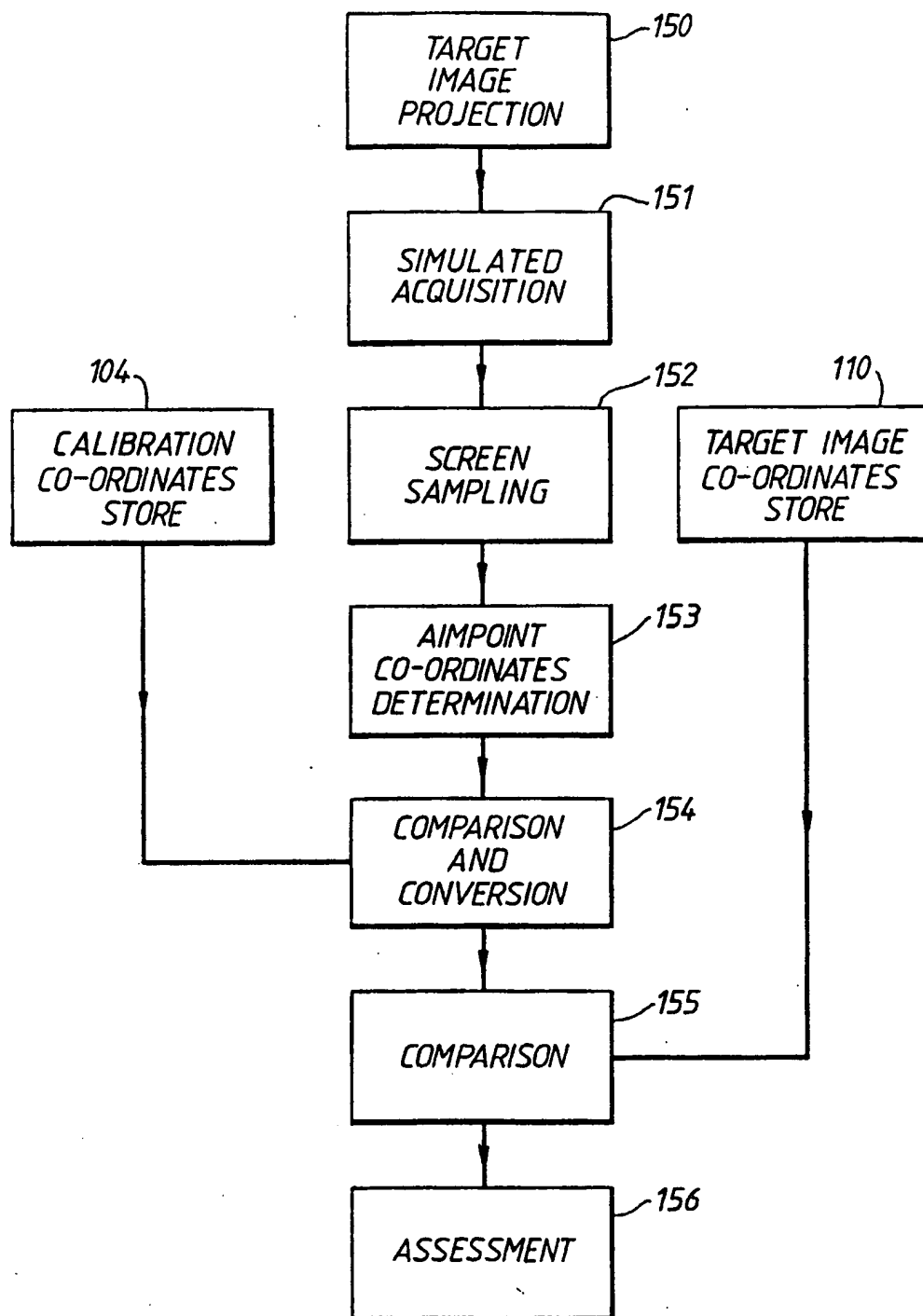


Fig.5

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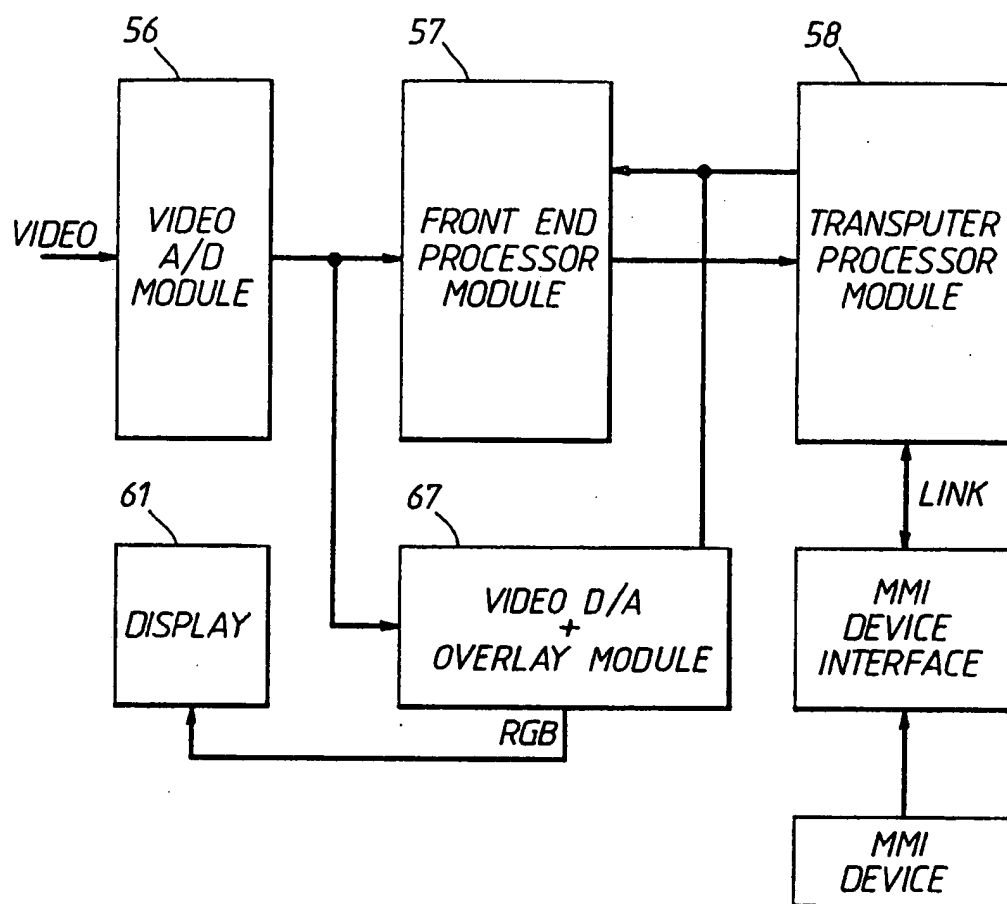
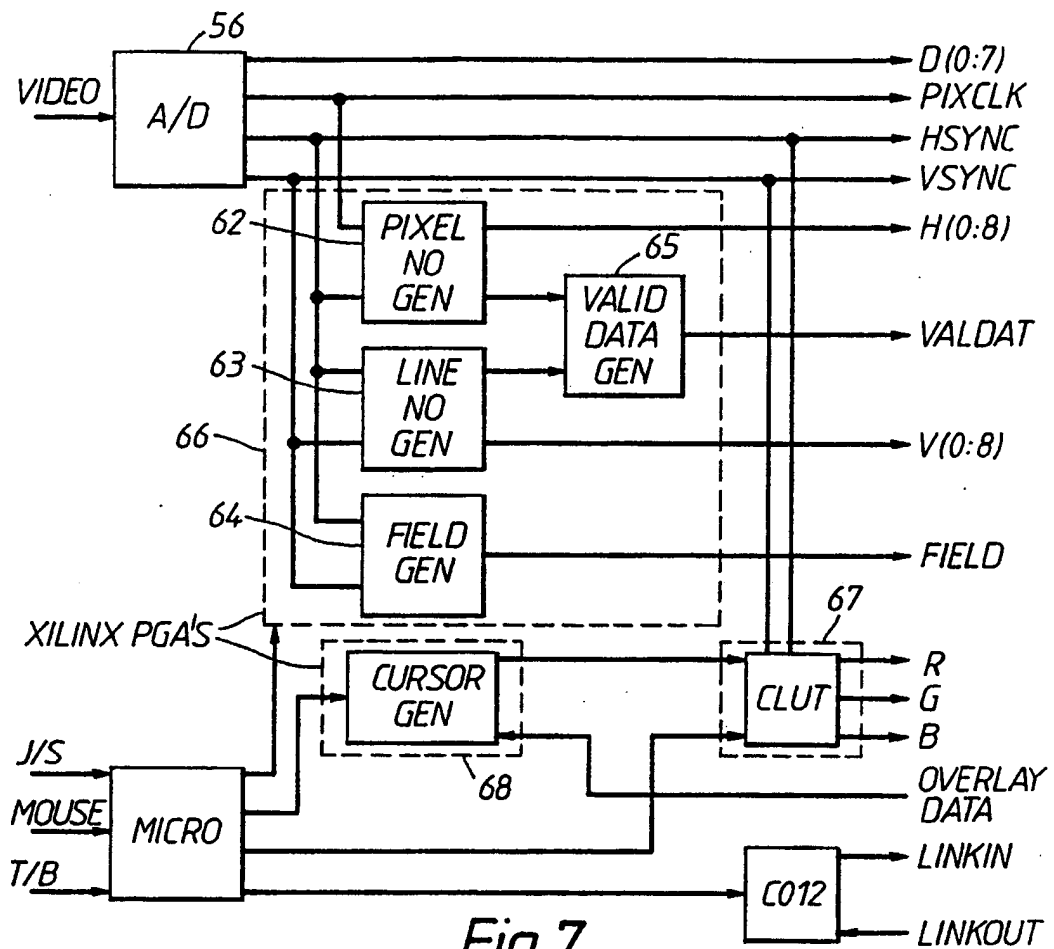


Fig.6

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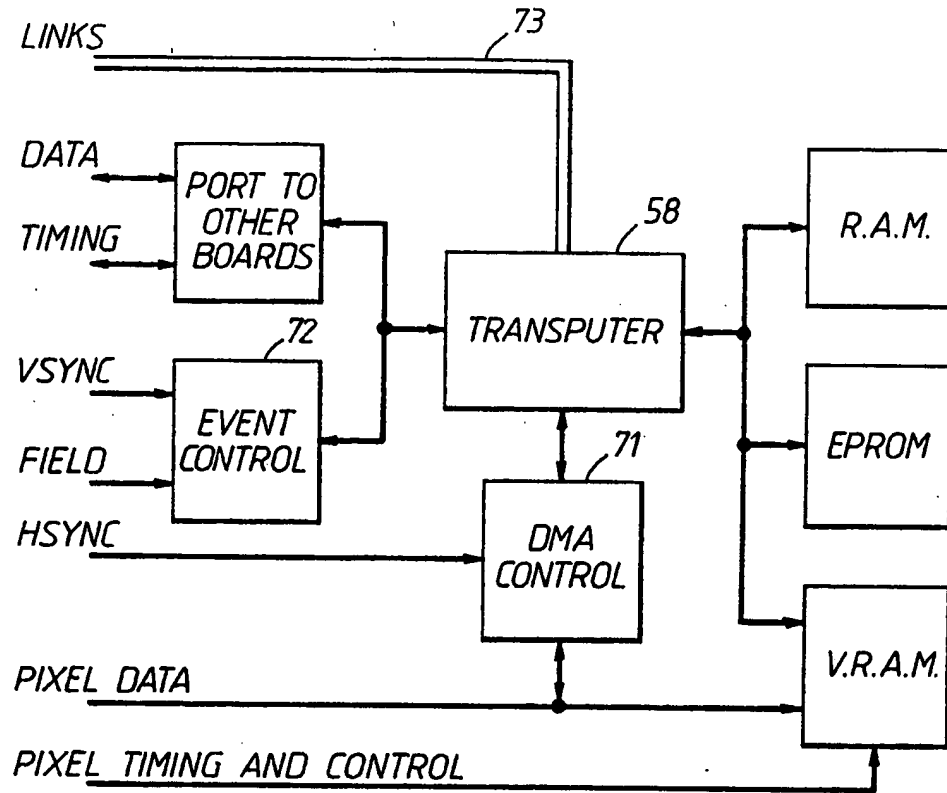


Fig. 8

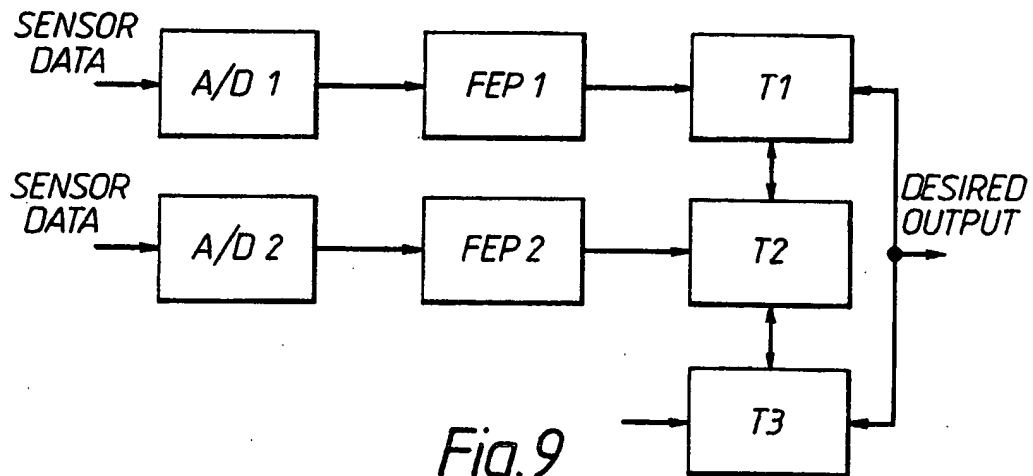


Fig. 9

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 93/02587

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 5 F41G3/26

According to International Patent Classification (IPC) or to both national classification and IPC:

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 F41G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 146 466 (GIRAVIONS DORAND) 26 June 1985 see abstract see page 6, line 23 - page 13, line 14; figures 1,2 ---	1,12,26, 34
A	GB,A,2 161 251 (FERRANTI PLC) 8 January 1986 see abstract see page 1, right column, line 120 - page 6, right column, line 98; figures 1-3 ---	1,12,26, 34
A	PATENT ABSTRACTS OF JAPAN vol. 15, no. 346 (M-1153)3 September 1991 & JP,A,03 134 499 (JAPAN RADIO CO LTD) 7 June 1991 see abstract --- -/--	1,12,26, 34

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

1 March 1994

Date of mailing of the international search report

17.03.94

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# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 93/02587

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>US,A,4 948 371 (HALL) 14 August 1990</p> <p>see abstract  see column 3, line 19 - column 9, line 64;  figures 1-7</p> <p>-----</p>	<p>1,12,26,  34</p>

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 93/02587

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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